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## A Conceptual Model of the Impacts of Networking on Innovative Performance of New Technology-Based Firms

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**Abstract**—In the recent past, several researchers explored the added-values of Science Parks. On the basis of empirical research, some questioned the assumed benefits of the science park model, whereas others reported positive outcomes. As a result, mixed findings regarding the benefits of science parks for firms can be observed. An important criterion in analyzing the effects of science parks is the level of networking as science parks often are regarded as a perfect location for inter-organizational knowledge exchange and collaboration. Different levels and types of networking could be one of the explanations for these mixed findings. The literature on networks mainly stresses the benefits of networking in general, and networking between firms located on science parks in particular. This paper proposes that networks can have both positive and negative effects for firms located on science parks. The aim of this study is to theoretically explore the impacts of networking on innovative performance of on-park and off-park firms. A conceptual model is developed including the main and interaction effects of various aspects of inter-organizational networks on innovative performance. Absorptive capacity is also included in the model to account for firm-specific abilities.

### I. INTRODUCTION

The majority of the currently existing science parks in the world were created during the 1990's and about 18% of the existing science parks have been launched in the first two years of the new century. This rapid growth of science parks attracted the interest of many researchers to undertake studies of science parks [7, 22, 23, 41, 74]. In the recent past, several researchers explored the added-values of science parks [19, 20, 41] by exploring the characteristics and performance of firms located on and outside science parks. These researchers showed that science parks provide an important resource network for on-park new technology-based firms (NTBFs) and that on-park NTBFs are likely to establish knowledge linkages. However, other researchers questioned the assumed benefits of the science park model [10, 58, 72] and found in their studies that firms do not gain any benefits from networking and clustering as well as from the linkages between academic research and industrial activity. Perhaps, different levels and types of networking could explain these mixed findings. This paper proposes that knowledge flows in networks can have both positive and negative effects for firms embedded in them. It distinguishes knowledge flow amongst organizations as 'intended' and 'unintended'. The effects of both types of knowledge flow is combined with geographical proximity. From the literature two contrasting views can be derived as to the effects of this specific combination. Alcacer and Zhao found in their study that firms

try to prevent the risk of unintended knowledge outflow by locating themselves further away from their competitors with similar technological backgrounds and in similar industries [2]. This implies that by clustering firms together (as on a science park) the probability of unintended knowledge flow is higher and thus the firms with leading technologies will, if possible, move away further from their competitors to prevent their technology being spillovered to them. On the other hand, the main purpose of science park location is to aggregate firms in related industries and supporting organizations (i.e., high geographical proximity) so that they are able to collaborate in research (intended knowledge exchanges). These contrasting views create a gap in the literature and lead to the main hypothesis of this paper: "The positive relationship between intended knowledge flows and innovative performance of firms will be negatively moderated by higher levels of unintended knowledge flows. This moderating effect is stronger for on-park firms as compared to off-park firms". The purpose of this study is to answer the following research questions:

1. What is the effect of knowledge transfer networks on the innovative performance of firms located on and off a science park?
2. What is the effect of unintended knowledge flow (knowledge spillover) on the innovative performance of firms located on and off a science park?
3. What is the combined effect of absorptive capacity and both types of knowledge flows on the innovative performance of firms located on and off a science park?

The aim of this study is to explore the effects of the interorganizational networking for NTBFs and compares their innovative performance of NTBFs on and off a science park. This will hopefully fill the gap of mixed findings of prior studies on the necessities of science parks to foster innovations. This paper covers the conceptual part of a research project currently being conducted. The remainder of this paper is structured as follows. Section two gives a brief background of the development of science parks around the world and its characteristics that form the focus of this study. Section three unfolds the literature of networks and knowledge flows with respect to innovations. Several hypothesis are formed to build the model of this study. Section four discusses the research methodology to be applied for the future data collection process. The final section will conclude this paper.

## II. SCIENCE PARKS ~ HISTORY OF DEVELOPMENT, DEFINITION AND CHARACTERISTICS

### A. History of development of science parks

Science parks are not a new phenomenon. The first science-based park, Standford Industrial Park (later resulting in the development of Silicon Valley), was established in 1951 in USA. In 1972, Cambridge Science Park was established in the UK. The majority of the currently existing science and technology parks in the world were created during the 1990's and 18% of the existing science parks have been launched in the first two years of the new century (IASP). The Association of University Research Parks (AURP) reports that there are 123 university-based science parks in the United States [38]. The UK Science Park Association (UKSPA) reported that in the UK there were 32 Science Parks in 1989 and 46 in 1999. In Asia today, there are more than 200 science parks with Japan topping the list with 111 initiatives. Today, there are over 400 science parks in the world and the number continues to grow rapidly due to regionally targeted initiatives introduced by governments and other organizations to provide an appropriate physical infrastructure for a successful local economy and social environment [40].

### B. Definition of science parks

Already in 1986, UKSPA gave a detailed definition by stating that a science park is a property-based initiative which

- (i) *has formal operational links with a university or other higher educational or research institution,*
- (ii) *is designed to encourage the formation and growth of knowledge-based businesses and other organizations normally resident on site,*
- (iii) *has a management function which is actively engaged in the transfer of technology and business skills to the organizations on site.*

Later, another science park association, The Association of University Related Research Parks (AURRP), stated in their Worldwide Research & Science Park Directory in 1998:

*The definition of a research or science park differs almost as widely as the individual parks themselves. However, the research and science park concept generally includes three components:*

- (i) *A real estate development*
- (ii) *An organizational program of activities for technology transfer*
- (iii) *A partnership between academic institutions, government and the private sector.*

A more recent visit to the website of the International Association of Science Parks reveals that their official definition of a science park is:

*A Science Park is an organisation managed by specialised professionals, whose main aim is to increase*

*the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities [29].*

Even though there are several definitions and an absence of uniformly accepted definitions for the term *science park*, these definitions outline the important aspects of a science park such as links with universities, management function in a science park, knowledge sharing environment to encourage innovations and creation of spin-off companies. In this paper, science parks are defined using the IASP's definition as it includes the most aspects of a science park

### C. Characteristics of science parks

The subject of science parks has generated a vast amount of literature and various aspects of science parks' characteristics are researched. These characteristics include:

#### 1) Clustering

High tech firms with similar characteristics (e.g.. sharing a common market for their end products, using a similar technology or labor force skills, or require similar natural resources) and / or within the same value chain (i.e. linked by buyer-seller relationships) would be attracted to cluster together as a strong allied group to compliment each other [10]. This phenomenon can be seen in science parks which are supposed to be a cluster of independent firms that are technology-related and knowledge-based and support organisations, with an emphasis on the presence of higher education institutions (HEIs). By clustering firms together in a specific region or on a specific location implies that there is a degree of 'geographical proximity', which facilitates knowledge flows. Studies have shown that maximum flow of information and ideas exist amongst geographically proximate firms [24] because this type of proximity supports the learning process through networking and thus positively influences the innovative outputs of firms [61].

#### 2) Academic-industry link

The progression of scientific knowledge to technological innovation lies within the core of science parks [55, 58], thus often a host academic institution (mainly HEIs) is formally associated with the park. This academic-industry link can take many forms [44, 58]:

- The transfer of people including founder-members of firms, key personnel and staff into employment in firms;
- The transfer of knowledge through collaborations with researchers and students of HEIs;

- Contract development, design, analysis, testing, evaluation, etc.;
- Access to university facilities;
- The establishment of 'academic spin-off firms', formed by academic staff taking research out of the laboratory and onto the science park, starting their own commercial enterprise

The presence of HEI often improves the prestige or image of science parks and often is a major factor for a firm's choice to locate on a science park [44, 73]. The contribution by HEIs has set the science park apart from other property initiatives and also helps to raise rental values.

### 3) Management function

From the UKSPA's definition of a science park it follows, that it has a management function which is actively engaged in the transfer of technology and business skills to the organizations on site. Johannisson [31] further explained a science park's management function as a formal administrative structure to manage the property on the park and/or to manage the delivery of auxiliary activities and professional services required by firms located on science parks, with a focus on channelling information and resources to the on-park firms [74] by providing networking services both internal amongst on-park firms and HEIs as well as external with customers, collaborators, and potential investors [71]. A managed science park is considered to have a general full-time manager or management company on-site whose principle task is to manage the park. As a conclusion statement, Westhead and Batstone pointed out that science parks generally need to strengthen their managerial functions with an emphasis on developing an effective way of linking tenant firms to the facilities and resources provided by a local HEI [74].

### 4) Knowledge flows

Firms located on science parks are bound in space and therefore more geographical proximate than rival firms located elsewhere. This agglomeration promotes the transmission of knowledge due to lower costs of communication in a dense environment. Researchers have distinguished two categories of transmission of knowledge: intended and unintended knowledge flows [18, 51]. If knowledge is exchanged with the intended people or organizations, it is "knowledge transfer", any knowledge that is exchanged unwillingly and outside the intended boundary is "knowledge spillover". When firms form networks (formal as via collaboration or informal as via social networking) in science parks, knowledge exchange occurs via these direct connections [16, 45]. Economists have been studying 'knowledge spillovers' as firms investing in research and development end up facilitating other firms' innovations by revealing their knowledge unintentionally [3, 46]. A firm can access unintended knowledge in various ways, such as

knowledge from reverse engineering on rivals' innovative products or knowledge from patents information.

## III. THEORETICAL FRAMEWORK AND CONCEPTUAL MODEL

### A. Networking for knowledge transfer

In the literature, there is a common emphasis on the importance of inter-organizational networks and networking for innovation through external acquisition of knowledge and information [15, 32, 56]. Many aspects of networks are studied in various literature but for the purpose of this paper, the emphasis is on pursuing networking for intended knowledge flows. Two levels of analysis can be seen in network studies: whole networks or egocentric networks. At the whole network level, the entire set of present and absent linkages amongst firms needs to be examined. For this study, the boundary of a science park network is difficult to be determined because on-park firms also have linkages with firms off-park. Therefore, the egocentric network level is chosen for this study because this approach considers only the direct linkages of a given firm ("Ego") and operationally, this usually relies entirely on Ego's self-reports about its network. Networks are studied here under three themes: degree centrality, tie characteristics (trust, proximities and knowledge quality) and diversity of actors.

### 1) Degree centrality and innovation

During the 1990's, innovation became faster and increasingly involved interorganizational networking [62]. By networking, firms are able to access knowledge externally from other actors and develop their own innovations. When firms interact formally (by explicit agreement) or informally (on a social basis), knowledge sharing often occurs and the resultant knowledge is available to partners. Evidence from literature illustrates that 'those firms which do not co-operate and which do not formally or informally exchange knowledge, limit their knowledge base over the long term and ultimately reduce their ability to enter into exchange relationships' [56]. Network position, such as centrality, is an important aspect of social structure because it conditions the degree to which an actor does have access to resources throughout the network. Centrality as a type of network position, measures the involvement of an actor in the network; the more a firm is involved in its network, the more it can compare information across multiple information sources and discover new information. More central firms are less likely to miss any vital information and are able to combine information in novel ways to generate innovations [70]. Various literature have shown that centrality is highly associated with innovation and enhances firm performance [6, 57, 76]. Centrality in this paper is examined using degree centrality that is measured by determining the number of direct relationships an ego firm has with other actors (so-called alters).

Hypothesis 1: The more direct ties that a firm maintains, the higher the firm's innovative performance

While most researchers pay attention to network structures [1, 11, 12, 65], other researchers argued that the characteristics of ties within networks cannot be neglected as they also influence the performance of actors [16, 25, 48]. Ties are connections between social nodes. In this study the nodes are organizations and the connection is the interactions between them for knowledge transfer. As mentioned earlier, some researchers have put more focus on the dynamics of ties/ relations rather than their structural configuration. Various aspects of ties dynamics can be considered such as purpose, direction, content, and strength [37]. This study focuses on knowledge as the tie content and therefore the purpose of a tie is aimed at knowledge sharing for innovations. The other two dynamics of ties, strength (associated with trust and proximity) and contents (quality of knowledge flowing in the tie), need to be explored to fully understand the characteristics of a tie.

## 2) Trust

The willingness of organizations to exchange information is often associated with tie strength [17, 27] and studies have identified trust in relationships as an important relational asset [67] that promotes the willingness of the exchanged knowledge. Trust can be defined as ‘the judgment one makes on the basis of one’s past interactions with others that they will seek to act in ways that favour one’s interests, rather than harm them’ [42]. From this definition, having trust can minimize risks that stem from exposure to opportunistic behaviour by partners. Based on past interactions, when two individuals are emotionally involved with each other and eventually trust is build between them, the more time and effort to transfer knowledge they will be willing to put forth on behalf of each other. This form of trust is often called the ‘intentions’ form of trust [35] because this refers to the belief that partners intend to uphold the commitments they made. Another form of trust is ‘competence-based trust’ which refers to the belief the partners have the capability to meet their commitment. With respect to this study, trust refers to the belief that a partner is capable (competence form of trust) to provide the knowledge your firm needs for innovations as well as the belief that your partner is willing to share such knowledge for the benefits of each other (intentions for trust). Therefore, the higher the trust levels, the more willing actors are to exchange knowledge and information. As a result of this exchange, actors can increase their innovative performance. Based on the above discussions, the following hypothesis is developed:

**Hypothesis 2:** The higher the level of trust a firm has with its actors, the higher the firm’s innovative performance.

## 3) Proximities

As mentioned by Gertler, “recent work on innovation and technology implementation suggests the importance of closeness between collaborating parties for the successful development and adoption of new technologies [21].” This closeness between actors can be considered as the ‘proximity’

concept which refer to “being close to something measured on a certain dimension” [33]. There are various dimensions of proximity and most of the time overlap in their meanings. For this study, the classification of proximity uses three dimensions based on Knobens and Oerlemans’ literature reviews on proximities.

In the study of innovation and knowledge transfer, there is an emphasis on the literature of geographical proximity. It is often defined as geographical distance expressed as a specified radius of each firm [52] or travel times / perception of these distance [8]. A short distance between two actors facilitates knowledge sharing and transferring of tacit knowledge in particular. Tacit knowledge transfer is enhanced through face-to-face contacts and therefore the spatial dimension becomes essential. The concept of proximity goes beyond geographical distance. Technological proximity refers to the similarities between actors’ technological knowledge, in other words, how related is the knowledge exchanged between them. Transferring of unrelated knowledge can cause difficulties in assimilation and application of the knowledge [9] because the firm that receives the knowledge is not capable to identify, assimilate and exploit knowledge coming from sources (relative absorptive capacity defined by Lane and Lubatkin [34]). The third dimension of proximity refers to ‘organizational proximity’. In Knobens and Oerlemans’ paper (based on Rallet and Torre [59]), organizational proximity is defined as “*the set of routines – explicit or implicit – which allows coordination without having to define beforehand how to do so. The set of routines incorporates organizational structure, organizational culture, performance measurements systems, language and so on*”. Collaborating firms that have low organizational proximities have different sets of routines and thus instead of creating innovations together, they create problems due to these routines and as a worst scenario, an unsuccessful collaboration leads to no innovative outputs. Based on the discussion above, proximities (in the three dimensions) between firms positively influence their collaboration and understanding of each other. Hence,

**Hypothesis 3:** The more innovating firms are proximate (geographically, technologically, organizationally) to their partners, the higher their innovative performance will be.

## 4) Knowledge qualities

Soo and Devinney’s paper found a positive relationship between knowledge quality and innovative performance [64]. The quality of knowledge comprises two factors: usefulness of the knowledge that a firm receives for its innovation and how frequent it receives the knowledge. The context of the knowledge that a firm receives directly influences the success of the innovative outcomes if the firm can actually use such knowledge. The knowledge can be new to the receiving firm, but if it cannot be used and contribute to the firm’s development of new innovation, then such knowledge has low knowledge quality to the firm. The frequency of receiving knowledge (knowledge transfer) also is a

dimension of the quality of the knowledge because more frequent communication can lead to more effective communication [60]. With frequent communication the receiving firm can better understand the knowledge that it receives and increase the chances that the knowledge is useful for the firm's innovation. It is also mentioned in the study of Audretsch and Feldman in 2004 that the marginal cost of transmitting knowledge, especially tacit knowledge, is lowest with frequent social interaction, observation and communication [4]. This leads to our fourth hypothesis as the following,

Hypothesis 4: The higher the usability of the acquired knowledge and the higher the communication frequency, the higher the innovative performance of firms.

### 5) Diversity of network actors

Many innovators derived their ideas from a diverse set of actors because these provide diverse ideas which is a source of novelty which can trigger new ideas and creativity in the knowledge acquiring firm. Actors who interact with partners from diverse communities of practice will be able to convey more complex ideas than those individuals who are limited to interactions within a single body of knowledge [60]. Diversity of actors in a network is important to innovation because it is not only the size of the network that maximizes information but also those actors found in networks composed of firms with different, but complementary knowledge [26, 66, 69]. Knowledge building often requires dissimilar, complementary bodies of knowledge from diverse actors [14]. Diversity is defined here as 'multiple sources of knowledge such as competitors, customers, suppliers, HEI, etc. that a firm has' with the hypothesis,

Hypothesis 5: The higher the diversity of actors that a firm has in its ego-network, the higher its innovative performance

### B. Unintended knowledge flows (Knowledge spillover)

Researchers [18, 28, 51, 68] refer unintended knowledge flows to the knowledge spillover literature. They define unintended knowledge flow as the knowledge transmission to other actors on an involuntary and unintended basis, or in other words, unintentional transmission of knowledge to others beyond the intended boundary. This type of knowledge flow can be acquired without the acknowledgement of the sending firms and often zero or low costs are involved. In various knowledge spillover studies, researchers attribute innovative performance to knowledge spillovers [18, 30, 51]. Therefore, we put forward hypotheses 6.

Hypothesis 6: Higher levels of unintended knowledge flows will result in higher firm innovative performance

In this study we assume that the relationship between intended knowledge flows (knowledge transfer) and innovative outcomes will be negatively influenced by higher levels of unintended knowledge flows because the moment

the sender-firms realizes that their knowledge is 'used' without their approval by the receiving-firms, this will lower their willingness to share knowledge in the official collaborations and/or informal networking activities. Hence, Hypothesis 7: The relationship between intended knowledge flows and innovative performance of firms will be negatively moderated by higher levels of unintended knowledge flows/spillovers.

### C. Absorptive capacity

From Cohen and Levinthal's study in 1990, firms' fundamental learning processes: its ability to identify, assimilate and exploit knowledge from the environment, is labeled absorptive capacity [13]. Zahra and George later reported additional definitions that separate Cohen and Levinthal's definition of absorptive capacity into two main dimensions: potential absorptive capacity (the capability to acquire and assimilate knowledge) and realized absorptive capacity (the exploitation or use of the knowledge that has been absorbed) [77]. Many empirical studies have shown that there is a positive relationship between absorptive capacity and innovation. Pennings and Harianto's study showed that prior accumulated experience in a certain technological area increased the likelihood of innovation adoption [54]. Becker and Peters [5] and Nelson and Wolff [47] argue that firms need higher absorptive capacities for scientific knowledge than for other types of knowledge. This shows that absorptive capacity is essential for the use of scientific knowledge which in turn is the base of radical innovation. Hence,

Hypothesis 8: Higher levels of absorptive capacity will result in higher firm innovative performance

Networking encourages the sharing of tacit and explicit knowledge among actors, but only firms with higher absorptive capacity levels are able to fully assimilate and exploit the absorbed knowledge for its innovation. Similarly, even if a firm is able to access unintended knowledge by monitoring other firm's innovative activities or using their patents, the firm still needs strong absorptive capacity to understand such knowledge for its own innovations and thus enhance its innovative performance. Therefore we include absorptive capacity in the interaction effects and thus the hypotheses 8 and 9.

Hypothesis 9: The relationship between intended knowledge flows and innovative performance of firms is positively moderated by higher levels of absorptive capacity.

Hypothesis 10: The relationship between unintended knowledge flows and innovative performance of firms is positively moderated by higher levels of absorptive capacity.

According to the above discussions, we put forward the theoretical model which illustrates the main effects (fig 1) and interaction effects (fig2).

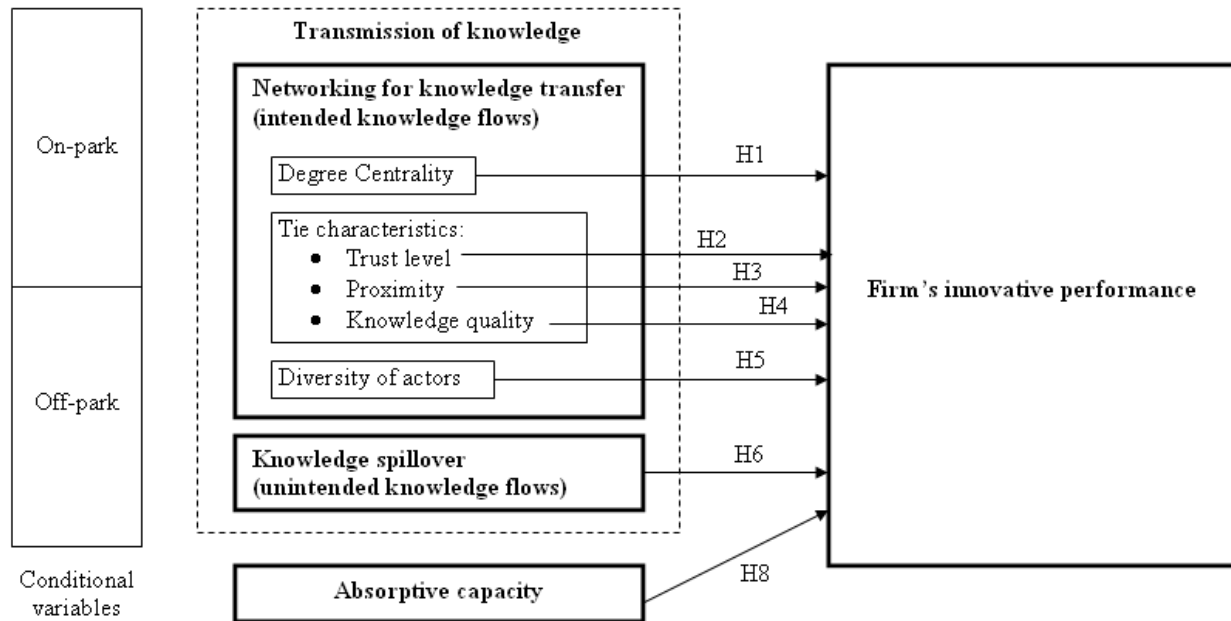


Fig. 1 The theoretical model showing the main effects

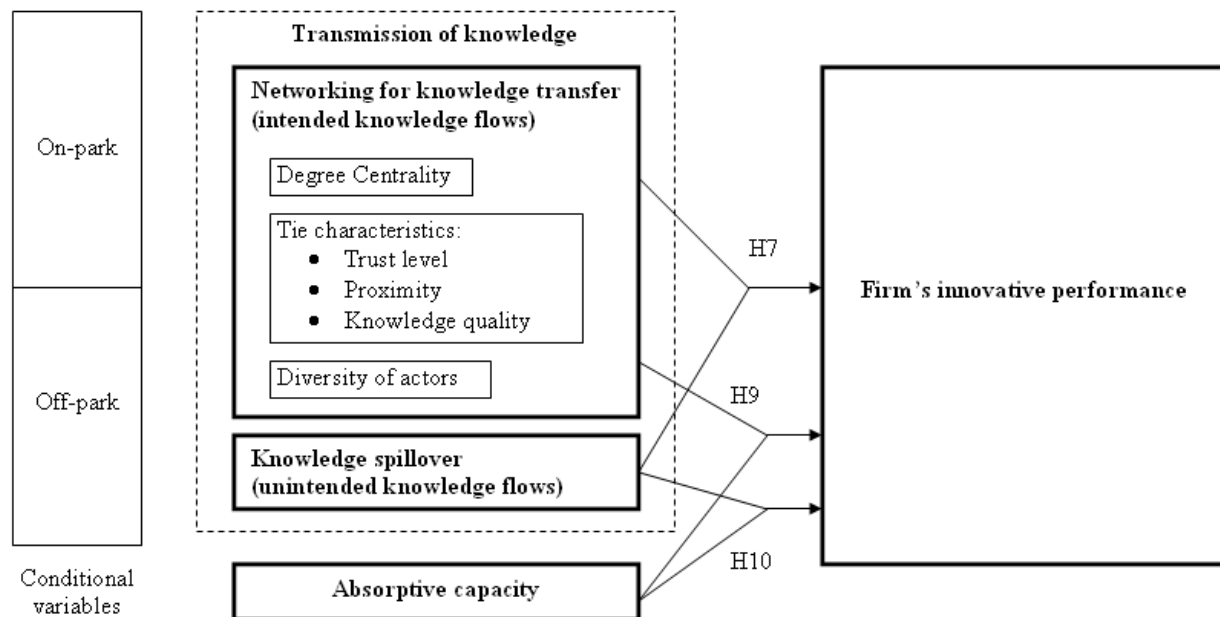


Fig. 2 The theoretical model showing the interaction effects

The main purpose of this study is to learn on a networking level (degree centrality, tie characteristics and diversity), knowledge spillover level and firm innovative performance level of any differences between firms that locate on science parks and those that locate elsewhere. This is the reason we include two conditional variables: on-park firms and off-park firms

#### IV. MEASUREMENTS AND RESEARCH METHODOLOGY

##### A. Measurements

The measurements for each of the variables are illustrated in Table 1 with the references. The questionnaire is designed based on these sources in the literature.

TABLE 1 MEASUREMENTS OF VARIABLES

Variables	Measurements
Degree centrality	Reference [53]: Number of direct connections that an actor (a node) has with other actors.
Trust level	Reference [39]: <i>Interorganizational trust</i> ( $\alpha = 0.94$ ) <ol style="list-style-type: none"> <li>Our customer keeps promises it makes to our firm</li> <li>Our customer is always honest with us</li> <li>We believe the information that our customer provides us</li> <li>Our customer is genuinely concerned that our business succeeds</li> <li>When making important decision, our customer considers our welfare as well as its own</li> <li>We trust our customer keeps our best interest in mind</li> <li>Our customer is trustworthy</li> <li>It is not necessary to be cautious with our customer</li> </ol> For each item, a seven-point Likert scale was used with response options ranging from strongly disagree to strongly agree Reference [75]: <i>Interpersonal Trust</i> ( $\alpha = 0.8799$ ) <ol style="list-style-type: none"> <li>My contact person has always been evenhanded in negotiations with me.</li> <li>I know how my contact person is going to act. S/he can always be counted on to act as I expect.</li> <li>My contact person is trustworthy.</li> <li>I have faith in my contact person to look out for my interests even when it is costly to do so.</li> <li>I would feel a sense of betrayal if my contact person's performance was below my expectations.</li> </ol> (1 = strongly disagree, 4 = neither agree nor disagree, 7 = strongly agree)
Geographical proximity	Reference [63]: Partner, and located: not a partner, same town/city, same province, other province, abroad
Technological proximity	Reference [9]: Concept of technology relatedness: To what extent is the knowledge your firm receives from the most partners/actors related to your firm's own knowledge?
Organizational proximity	Reference [33]: Organisational proximity between the focal firm and its main direct IOR is measured by asking firms (on 5 point Likert scale) to react on the statements with regard to whether or not the main IOR has <ul style="list-style-type: none"> <li>the same other partners (relation dimension)</li> <li>the same organizational norms and values (institutional and cultural dimension)</li> <li>the same organizational structure (structural dimension)</li> </ul>
Knowledge qualities	Reference [64]: To measure the construct of knowledge quality, a three-step approach was taken: <ol style="list-style-type: none"> <li>respondents were asked to rate the frequency of acquiring knowledge from 10 sources</li> <li>respondents were asked to rate the usefulness and innovativeness of the knowledge that is acquired from each of the listed sources. Preliminary analyses showed a strong correlation between the usefulness and innovative scores, and thus both are combined to form a 'quality' score</li> <li>both "frequency" and "quality" scores are combined to form the measure for knowledge quality</li> </ol> Reference [36]: Frequency of communication: How often did you communicate with each person? 1= daily; 2= twice a week; 3=once a week; 4=twice a month; 5= once a month; 6=once every 2 <sup>nd</sup> month; 7=once every 3 months or less.
Diversity of actors	Reference [50]: External information sources were categorised in specific groups: the business network (competitors, buyers and suppliers), the public and private knowledge infrastructure (innovation centres, public research labs, universities, consultants and sector institutes), and professional information channels (professional literature, exhibitions, patents and electronic databases). Respondents were asked to rate from 1 to 4 to indicate which knowledge sources were used for the firm's technological innovation. (1= source not used, 2= of little importance, 3= important, 4= very important) (For our study, professional information channels will not be included in the questionnaire because they are not actors that firm can collaborate with. From the distribution of the sources, we can determine how diverse that actors are)



Knowledge spillover (Unintended knowledge flows)	<p>Reference [28]:</p> <p>The unintended knowledge transfer include:</p> <ul style="list-style-type: none"> <li>• departure of key scientists and engineers (including poaching of key staff)</li> <li>• informal know-how sharing</li> <li>• unintended signaling of key information at conferences and workshops</li> <li>• membership of 'invisible colleges' and research schools</li> <li>• professional links associated with specific 'communities of practice'</li> <li>• related to membership of professional associations or informal groupings</li> <li>• unintended leakage by consultants</li> <li>• design practices of information picked up from one client and applied to others.</li> </ul>
Absorptive capacity	<p>Reference [49]:</p> <p><u>Measures of the firm's absorptive capacity</u></p> <p>Level of knowledge and experience of the organization: Indicate level of agreement with the following statements (on a scale from 1 to 5):</p> <ul style="list-style-type: none"> <li>• Most of our staff are highly skilled and qualified</li> <li>• We invest a great deal in training</li> <li>• We innovate by improving competitors' products and processes</li> <li>• Most of the time we are ahead of our competitors in developing and launching new products</li> <li>• We have the capacity to adapt others' technologies</li> <li>• We innovate as the result of R&amp;D carried out within our own firm</li> <li>• The firm has a capacity for technological development allowing us to introduce onto the market innovations which are completely novel on a worldwide scale</li> <li>• We have considerable capacity for technological development</li> </ul>
Firm's innovative performance	<p>Reference [43]:</p> <p>Innovative performance is a mean score of eight items indicating performance improvements due to product and process innovations. Managers were asked to judge the performance improvements due to process and product innovations on a Likert scale with values 1= very little to 5= very much. For process as well as product innovations the items were</p> <ul style="list-style-type: none"> <li>• contribution of innovation to cost cutting</li> <li>• increase of turnover</li> <li>• increase of profits</li> <li>• quality improvement.</li> </ul> <p>Reference [51]:</p> <p><u>Indicators for the measurement of relative innovative performance:</u></p> <ol style="list-style-type: none"> <li>1. relative percentage of new processes and products between 1989 and 1994 ~ firms were asked to indicate which percentage of the processes and products was new to the firm in a 5 – year period</li> <li>2. relative scope of innovation results ~ firms were asked to indicate to what extent process and/or product innovations resulted in: <ul style="list-style-type: none"> <li>• reductions of cost prices</li> <li>• quality improvements of processes and / or products</li> <li>• increases of production capacity</li> <li>• improvement in delivery time</li> <li>• increases in sale</li> <li>• increases in profits</li> </ul> </li> </ol> <p>(a compound variable was calculated as the average sum score of the items mentioned above)</p> <p>Reference [8]:</p> <p><u>Innovative performance is measured by:</u></p> <ul style="list-style-type: none"> <li>• number of product innovations</li> <li>• number of process innovations</li> <li>• share of innovative sales in last year's turnover</li> </ul>

### B. Research methodology

Science Parks provide an important resource network for new technology-based firms (NTBFs). Therefore the unit of analysis is NTBFs. The Science park that will be studied is the Innovation Hub in Pretoria, South Africa. The number of current on-site firms under sectors is as follows:

- Bioscience: 5

- Electronics: 2
- Engineerings: 6
- Information, communication and technology (ICT): 29
- Smart manufacturing: 1
- Professional services: 4
- Clients in incubator (Maxum Business Incubator): 4

This adds up to a total of 51. In literature, there are two main ways of sampling which are relevant for this research framework: matching sampling and stratified sampling. In this study matching sampling is preferred because stratified sampling strategy will lower the numbers of on-park firm samples and there is already a low number of on-park firms in the Innovation Hub. Therefore for this study, conducting cross-sectional comparison is advised. The identification of comparable off-park firms will be done by matching them with a similar group of on-park firms based on the selection criteria (control variables):

- Sectors (comparable to the sectors of the science parks)
- Independency of firms (off-park firm should not be under a big company; there should not be a parent firm)
- Regions: Gauteng (as it is the economic concentrated area in South Africa and where the Innovation Hub is situated)
- Age of the firm
- Size of the firm

This research will apply a combined qualitative and quantitative research methodology. Questionnaires will be gathered from the managers of the NTBFs in the Innovation Hub and comparable NTBFs not locating in the Innovation Hub. Statistics tools such as SPSS will be applied to analyze the collected data. Together with surveys, two case studies will be done to confirm the results from the surveys.

## V. CONCLUSIONS AND FUTURE RESEARCH

The proposed theoretical model explicitly acknowledges the impacts of two types of knowledge flows, intended knowledge flow (knowledge transfer through networking) and unintended knowledge flow (knowledge spillovers), on a firm's innovative performance. Absorptive capacity is included in the model to account for firm-specific abilities influencing the processing of acquired knowledge. The reason is that absorptive capacity influences a firm's ability to translate intended and / or unintended knowledge into its own innovation activities and outcomes. The independent variables also include elements of networks. These are broken into three categories: degree centrality (number of direct ties), tie characteristics (trust, proximities and knowledge qualities) and diversity of network actors. The figures 1 and 2 illustrate the hypotheses which were developed based from the above mentioned variables' main effects and interaction effects on firm innovative performance. It is important to compare the innovative performance of NTBFs on and off a science park if we want to explore the benefits of a science park location. Therefore, firms were classified into one of two categories: on-park firms in the Innovation Hub and off-park firms.

This paper proposes that inter-organizational networks can have both positive and negative effects for firms located on science parks. From the literature two contrasting views can be derived as to the effects of this combination. On the one hand, firms try to prevent the risk of unintended

knowledge outflow by locating themselves further away from their competitors with similar technological backgrounds and in similar industries [2]. Because firms located on science parks do not have a relocation option in the short run, this might imply that intended knowledge flows will be lower. On the other hand, it is assumed that location of firms in related industries and supporting organizations located on science parks (i.e., high geographical proximity) fosters and encourage knowledge flows and collaborations. These contrasting views can be regarded as a gap in the literature and lead to the main hypothesis of this paper: "The positive relationship between intended knowledge flows and innovative performance of firms will be negatively moderated by higher levels of unintended knowledge flows. These effects are stronger for on-park firms as compared to off-park firms". The reason is that close geographical proximity enables on-park firms to monitor co-located firm's innovation activities and which enhances the chance of imitation. Sender-firms can relatively easily identify which on-park firms imitate their innovations and as a result this will lower their willingness to share knowledge in formal collaborations and/or informal networking activities with on-park firms. As a result, innovative performance of firms might suffer, i.e., lower innovative performance as a whole in science parks.

So far, the proposed model has not been empirically validated yet. However, at this very moment questionnaires are developed for both categories of firms, which will be sent to the managing directors of these firms in South Africa. Future research should attempt to identify and examine additional contingent linkages and interrelationships. On-park firms from various science parks can also be used as samples for a comparative study. Results of these future studies, coupled with previous findings and the model proposed here, will enhance our understanding of the interrelationships amongst networking, absorptive capacity, science park location and firm innovative performance.

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